

## Image Quality in Pediatric Imaging in Association with Use of Sedation and General Anesthesia

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### ABSTRACT

**Introduction:** The accuracy of image interpretations of CT and MRI studies is absolutely dependent on the quality of the images produced. Motion artifacts which result from the patients' movement during image acquisitions may lead to misinterpretation, wrong diagnosis or inconclusive examinations. In pediatric age groups, most of CT and MRI examinations require sedation or general anesthesia to achieve the degree of cooperation or immobilisation to complete the procedures successfully. **Methods:** The patients were randomly chosen among children, from newborn to 12 years of age who underwent sedation and general anesthesia for CT scan and MRI in the University of Malaya Medical Centre between September 2001 and August 2003. The quality of MRI and CT images were evaluated by radiologists using a three-point scale: 1- no motion artifact; 2- minor motion artifacts and 3- major motion artifacts. **Results:** Among sedated children, 75.5% and 41% had good CT and MRI images respectively. In general, the anesthesia group, 100% had good CT images and 85.7% had good MRI images. Children who received sedation (33.5%) had severe motion artifacts whereas none of the anesthetised children had severe motion artifacts. **Conclusion:** General anesthesia is much better for good quality images in both MRI and CT examinations; however it is associated with a higher cost and longer hospital stay. Combination of oral chloral hydrate and intravenous midazolam was found to be the most effective sedative agent in terms of CT/ MRI image quality.

**Keywords:** Image quality, pediatric imaging, sedation, general anesthesia

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### INTRODUCTION

The use of sedation and general anesthesia for pediatric radiological imaging has increased dramatically particularly with the introduction of CT scan and MR imaging.<sup>[1]</sup> In children, most of these procedures require sedation or general anesthesia to achieve the degree of cooperation or immobilisation necessary to complete these procedures successfully. Sedation and general anesthesia are more often used for MRI than for CT.<sup>[2]</sup> As MR imaging for most studies takes a long time to be completed, general anesthesia is preferable compared to sedation. With limited availability of open MRI, sedation or general anesthesia is also used to overcome the problem of claustrophobia among the patients.

The accuracy of image interpretation of CT and MRI studies is absolutely dependent on the quality of the images produced. Motion artifacts may obscure important findings for accurate diagnosis or may lead to misinterpretation. The problem of motion artifacts also leads to repeating the same studies which are not cost-effective and results in delay in instituting appropriate management to the patients.

## METHOD

### *Study Group*

The patients for this study were randomly chosen from among the children, from newborn to 12 years of age who underwent sedation and general anesthesia for CT scan and MR imaging in the University of Malaya Medical Centre between September 2001 and August 2003. Both inpatients and outpatients were included. Two hundred children who fulfilled the selection criteria were included in the study. Of the 200 children, 114 patients underwent CT scan and 96 patients underwent MRI. One hundred and eleven (55.5%) were females and 89 (44.5%) were males. There were 103 (51.5%) Chinese, 58 (29.0%) Malays and 39 (19.5%) Indians.

### *Study Design*

This study was conducted in the CT and MRI diagnostic areas at the University of Malaya Medical Centre, a tertiary care medical centre. It was a prospective study involving cooperation between Radiology, Pediatrics and Anesthesiology departments. Children who were intubated or ventilator-dependent or both were excluded from the study

### *Sedation*

Institutional sedation guidelines based on recommendations by the American Academy of Pediatrics (AAP) and the American College of Radiology (ACR) were in place at the time of this study. In accordance with these guidelines, sedatives were ordered at the discretion of the child's pediatrician based on the child's underlying medical history and physical examination. The pediatric doctors administered all the sedatives and monitored the children throughout the procedure under the supervision of the radiologists. Monitoring included continuous pulse oximetry in every case. Arterial pressure was measured before and after the procedure and more frequently at the discretion of the caregiver. Depth of sedation was assessed at least every 15 minutes by evaluating response to sound, verbal commands or tactile stimulation.

### *General Anesthesia*

The decision to use general anesthesia was made by the pediatricians in charge of the patients and the reasons for this decision were documented. Decisions were based on guidelines developed by a multidisciplinary committee, which recommended an anesthesiology consultation for children at risk for sedation-related adverse events such as airway abnormalities and underlying cardiopulmonary disease. Following informed consent, management for children who received general anesthesia was at the discretion of the attending anesthesiologist assigned to the care of the child. Care and monitoring were in accordance with mandates from the Joint Commission on Accreditation of Health Care Organizations (JCAHO) and ASA recommendations. The drugs used were a combination of Sevoflurane with either Atracurium, Thiopentone or Isoflurane.

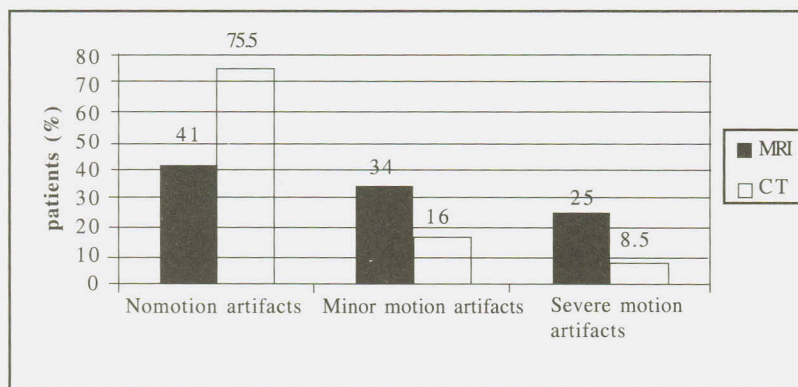
The quality of random samples of MRI and CT scans were evaluated by radiologists. These scans were scored using a three-point scale: 1- no motion artifact; 2- minor motion artifacts and 3- major motion artifacts making another scan necessary. Data was collected by the principal investigator and tabulated using Microsoft Excel 1998 and analysed by SPSS 11.0.

## RESULTS

### *Quality of MRI and CT in the Sedation and General Anesthesia Groups*

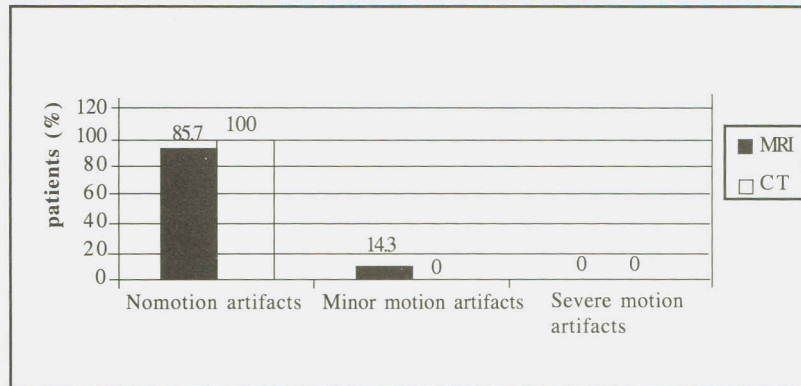
Of the 150 children who were given sedation, 106 of them were for CT scan and the rest were for MRI. Of the 106 children who were sedated for CT scan, 80 children (75.5%) had good CT images without motion artifacts. Seventeen children (16.0%) had CT images with minor motion artifacts whereas 9 children (8.5%) had poor CT images with major motion artifacts which required a repeat CT with either general anesthesia or sedation with different sedative agents.

Among children who underwent MRI under sedation, 18 children (41.0%) had good MRI images without motion artifacts. Fifteen children (34.0%) had MRI images with minor motion artifacts whereas 11 children (25.0%) had poor MRI images with major motion artifacts which required a repeat with either general anesthesia or sedation with different sedative agents. Fifty children were given general anesthesia, 42 for MRI and the other 8 for CT scan. Of the 42 children who underwent general anesthesia for MRI, 36 children (85.7%) had good MRI images without motion artifacts and six children (14.3%) had MRI images with minor motion artifacts. None of the children had MRI images with major motion artifacts. All children who underwent general anesthesia for CT scan had good images without motion artifacts. *Figs. 1 and 2* show quality of MRI and CT in the sedation and general anesthesia groups respectively. *Fig. 3* demonstrates CT/ MRI images with motion artifacts.

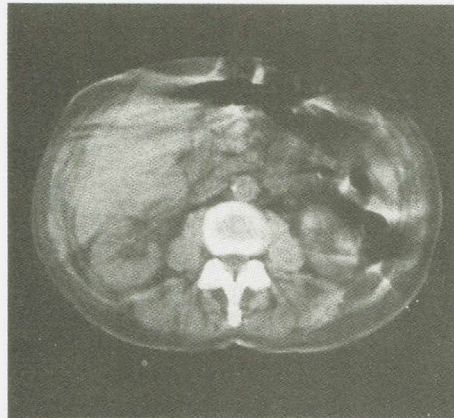


**Figure 1:** Quality of MRI and CT in the sedation group

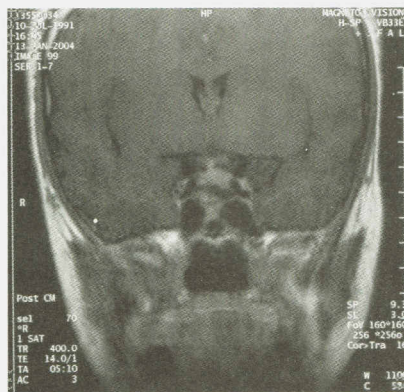




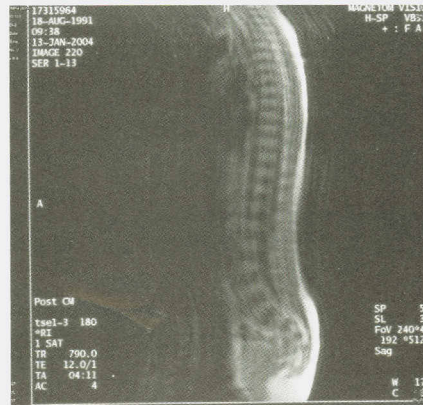
**Figure 2:** Quality of MRI and CT in the general anesthesia group



**Figure 3a:** CT image of a sedated 4-year-old child with major motion artifacts



**Figure 3b:** Coronal MRI of pituitary fossa with minor motion artifacts of a 5-year-old boy who was given general anesthesia



**Figure 3c:** CT image of a sedated 4-year-old child with major motion artifacts

#### *Quality of MRI and CT in Relation to Sedative Agents Used*

A combination of chloral hydrate and midazolam gave the best quality of MRI and CT scans without motion artifacts in 27 of the patients (71.1%). This was followed by chloral hydrate and midazolam as single agents in 34 (63.0%) and 22 (43.1%) respectively. The most severe motion artifacts were seen in children who were given chloral hydrate alone; this constituted 9 patients (16.6%). Midazolam as a single agent resulted in severe motion artifacts in 7 patients (13.7%) whereas a combination of midazolam and chloral hydrate gave poor MRI/CT images in 3 patients (7.9%). Table 1 shows the quality of MRI and CT in relation to sedative agents used.

**Table 1.** Quality of MRI and CT in relation to sedative agents used

	MRI/ CT motion		Artifacts			
	Number		Minor		Severe	
	n	%	n	%	n	%
Chloral hydrate	34	63	11	20.3	9	16.7
Midazolam	22	43.1	9	17.6	7	13.7
Chloral hydrate + Midazolam	27	71.1	8	21	3	7.9
Midazolam + Ketamine	1	0.5	1	0.5	0	0
Midazolam + Pethidine	1	0.2	3	0.6	1	0.2

## DISCUSSION

In this era of medical care, the earlier an accurate diagnosis obtained, the faster the patient's management can be instituted. This in turn is associated with a higher percentage of curability and markedly reduced patients' morbidity and mortality.

CT scan is the imaging modality of choice in the majority of the cases to assist in diagnosis of the disease as well as to assess response to the treatment given. MRI is currently widely accessible in most public and private medical centers. Both imaging modalities provide excellent images in different planes (for CT, the original axial images need to be retro-reconstructed) to be viewed in assisting the patients' management.

However, the accuracy of image interpretations of CT and MRI studies is absolutely dependent on the quality of the images produced, as well as the completeness of the examinations. The most common problem encountered in pediatric imaging is motion artifacts. It is an avoidable problem or at least it can be minimised with the use of sedation or general anesthesia to achieve the degree of cooperation or immobilisation necessary to complete these procedures successfully. Motion artifacts are culprits to accurate diagnosis, may lead to misinterpretation or an inconclusive study. Most times, this problem results in repeating the same examination which compound the charges to the institution and third party payers. In addition, it is costly to patients and families in terms of travel time, repeated trips to the hospital, loss of work time and most importantly, delayed diagnosis which is immeasurable.

From our study, among children who were sedated, 75.5% had good CT images and 41% had good MRI images without motion artifacts. In general, 100% of the anesthesia group had good CT images and 85.7% had good MRI images. Those children who received sedation (33.5%) had severe motion artifacts whereas none of the anesthetised children had severe motion artifacts. This proves that general anesthesia is much better than sedation in achieving the degree of immobilisation required. However, direct comparisons between children who received sedation and those who received general anesthesia were not done since it was not possible to randomise children to either group. Children who underwent general anesthesia were pre-selected based upon high risk criteria in some cases and expected duration of the procedure in others, and as a result, statistical comparisons between groups would be inappropriate. In general, general anesthesia appears to be more efficient in terms of time to onset of the procedure but results in a longer duration of recovery in the hospital. The increased costs associated with administration of general anesthesia therefore include added costs related to recovery. Although general anesthesia may cost more to be administered compared to sedation, in our patients it helped scans to be completed with negligible motion artifacts and a low incidence of adverse events. The costs of general anesthesia for a selected high-risk group of patients may be offset to some extent by the increased costs related to failed procedures.

A combination of oral chloral hydrate and intravenous midazolam was found to be the most effective sedative agent in terms of CT/ MRI image quality. However, as experienced by other studies<sup>[3]</sup>, this combination of sedative agents was associated with high incidence of adverse events in our patients, that is, hypoxemia, restlessness and gastrointestinal effects. We had two fatalities which were due to cardiac arrest and respiratory arrest, respectively. This combination of sedatives can still be used under strict precautions and monitoring with a careful selection of low risk patients.

## **CONCLUSION**

Among children who were sedated, 75.5% had good CT images and 41% had good MRI images. In general, 100% of the anesthesia group, had good CT images and 85.7% had good MRI images. A combination of oral chloral hydrate and intravenous midazolam was found to be the most effective sedative agent in terms of CT/ MRI image quality despite a high incidence of adverse events.

## **REFERENCES**

- [1] Fisher DM. Sedation of pediatric patients: an anesthesiologist's perspective. *Radiology* 1990; 175: 613-615
- [2] Keeter S, Benator RM, Weinberg SM, Hartenberg MA. Sedation in pediatric CT: national survey of current practice. *Radiology* 1990; 175: 745-752
- [3] Malviya S, Voepel-Lewis T, Eldevick OP, Rockwell DT, Wong JH, Tait AR. Sedation and general anesthesia in children undergoing MRI and CT: adverse events and outcomes. *British Journal of Anesthesiology* 2000; 84(6): 743-748